Reducing Impacts of Goods Movement in the Inland Empire

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CLIMATE SMART TRANSPORTATION AND COMMUNITIES CONSORTIUM
(a Strategic Growth Council Project)

Inland Empire Regional Initiative

- UC Davis (ITS)
- UC Berkeley (LBNL)
- UCLA (Luskin Center)
- UCR (CE-CERT & CSI)
- UC Irvine (ITS)
Reducing Impacts of Goods Movement in the Inland Empire

Context

There is explosive growth of warehousing in the Inland Empire, with little attention on transportation needs

• how do these warehouses and associated truck traffic affect residential neighborhoods?
  – Roadway safety
  – Traffic congestion
  ➢ Air quality and pollutant exposure to residents
Reducing Impacts of Goods Movement in the Inland Empire

Our Research Tools:

- Heavy Duty Electrification
  - Electric Trucks (currently being tested in pilots)
  - Vehicle charging infrastructure
- Connectivity and (partial) Automation
  - Increased efficiency and safety
  - Driving Assistance, not Driver Displacement
- Advanced Fleet Management tools, including low exposure truck routing, dynamic time-of-day scheduling, geofencing

From VolvoLights Project:
https://www.lightsproject.com/
Novel Electric Truck Dispatching Algorithms

- Optimize dispatching of electric trucks considering their driving range, estimated energy consumption, state of charge (SOC), charging needs, etc.
- Route electric trucks onto “eco-routes” with estimated time of arrival (ETA) within the arrival time window, if available.

Vehicle Routing: 
*fastest route, eco-route, low-exposure route*

- Most trucks use navigation based on achieving the fastest route.
- “Eco-routes” can be chosen that reduce fuel consumption, with a small travel time penalty.

Low-exposure routes can be chosen that reduce exposure of pollutants to local residents ← this is what we are doing as part of this grant.
Case Study: San Bernardino Airport Area

- Cargo to/from LA via I-10
- Cargo to/from LA via 60
- Cargo to/from LA/OC/ports via 215 then 91
- Cargo to/from US via I-10

Expanded to a major cargo air hub

Population
- 0 - 2
- 3 - 48
- 49 - 96
- 97 - 1309

Amazon
San Bernardino Airport at 10am of a typical weekday

Facility Population
- 70 - 283
- 284 - 512
- 513 - 664
- 665 - 2732

Census Block 2018 Population
Working Hour
- 1
- 2 - 28
- 29 - 57
- 58 - 3505

Road Network PM2.5
IM of total population (µg/kg mass)
- 0.000
- 0.001 - 0.003
- 0.004 - 0.009
- 0.010 - 5.277

Wind Direction @ 10am

Sensitive receptors (schools, assist. living, etc.)

General population density

Roadway exposure rating
San Bernardino Airport at 10am of a typical weekday

Example Route Analysis

- Starting Point: Freeway I-215 South & 210
- Ending Point (warehouse(s)) = Star
- Baseline Route = A → Coral Route
- Alternative Route = B → Green Route

<table>
<thead>
<tr>
<th>Route</th>
<th>Driving distance (mile)</th>
<th>Driving duration (min)</th>
<th>PM$_{2.5}$ (\mu g)</th>
<th>CO$_2$ (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coral, fastest route</td>
<td>11.45</td>
<td>12.99</td>
<td>101.77</td>
<td>18.65</td>
</tr>
<tr>
<td>Green, LER</td>
<td>8.16</td>
<td>13.32</td>
<td>97.45</td>
<td>13.73</td>
</tr>
</tbody>
</table>
Truck Volume Analysis

- Caltrans PeMS Truck Flow at mainline loop detector stations (LDS)
- Truck volume loading into the hub from four corners of the area is estimated

San Bernardino Airport at 10am of a typical weekday

PeMS Truck volume estimation reference: Kwon et al.
San Bernardino Airport at 10am of a typical weekday

Summary of Low-Exposure Routing (in progress)

<table>
<thead>
<tr>
<th>Corner #</th>
<th>No. of Trucks</th>
<th>Driving Distance (miles)</th>
<th>Driving duration (min)</th>
<th>PM$_{2.5}$ IM (ug)</th>
<th>NO$_x$ IM (mg)</th>
<th>CO$_2$ (kg)</th>
<th>Driving Distance (miles)</th>
<th>Driving duration (min)</th>
<th>PM$_{2.5}$ IM (ug)</th>
<th>NO$_x$ IM (mg)</th>
<th>CO$_2$ (kg)</th>
<th>Difference (v.s. Fastest route)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>56</td>
<td>641</td>
<td>728</td>
<td>203</td>
<td>19</td>
<td>1044</td>
<td>457</td>
<td>634</td>
<td>189</td>
<td>24</td>
<td>769</td>
<td>-184</td>
</tr>
<tr>
<td>2</td>
<td>11</td>
<td>103</td>
<td>143</td>
<td>13</td>
<td>1</td>
<td>157</td>
<td>88</td>
<td>146</td>
<td>8</td>
<td>1</td>
<td>141</td>
<td>-15</td>
</tr>
<tr>
<td>3</td>
<td>133</td>
<td>630</td>
<td>967</td>
<td>180</td>
<td>18</td>
<td>1108</td>
<td>659</td>
<td>1268</td>
<td>83</td>
<td>9</td>
<td>1144</td>
<td>29</td>
</tr>
<tr>
<td>4</td>
<td>186</td>
<td>1064</td>
<td>1512</td>
<td>111</td>
<td>12</td>
<td>1851</td>
<td>1074</td>
<td>1731</td>
<td>83</td>
<td>22</td>
<td>1898</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>386</td>
<td>2438</td>
<td>3349</td>
<td>507</td>
<td>51</td>
<td>4161</td>
<td>2278</td>
<td>3780</td>
<td>364</td>
<td>56</td>
<td>3951</td>
<td>-160</td>
</tr>
</tbody>
</table>

**General Conclusion:** we can achieve a 28% reduction in pollutant exposure and reduce fuel consumption by 5%, but will increase travel time by 13%
Refined Analysis with Traffic Signals

- Previous analysis assumed roughly constant speeds, with no stopping
- This analysis examines the effect of stopping at stop lights (~40 second lost per stop), and the pollutants they emit

- Stop lights make previous low-exposure routes less effective
- Traffic signals synchronized with vehicle traffic can improve the performance
Other Related Technology that can be Utilized

**Eco-Approach and Departure**

- V2I Communications: SPaT and GoP Messages
- V2V Communications: Basic Safety Messages
- Vehicle Equipped with the Eco-Approach and Departure at Signalized Intersections Application (CACC capabilities optional)

Source: Noblis, November 2013

**Freight Signal Priority**

- V2I Communications: BSM + Environmental Data + Signal Priority Request (may include schedule adherence, number of passenger, etc.)
- Traffic Signal System at a TMC or System in the Field
- Priority Data sent to the Traffic Signal Controller
- Determine if Eco-Traffic Signal Priority Should be Granted

Source: USDOT, February 2014
Eco-Approach and Departure Speed Advice to Drivers

- Application utilizes traffic signal phase and timing (SPaT) data to provide driver recommendations that encourage “green” approaches to signalized intersections
- Example scenarios:
  - Coast down earlier to a red light;
  - Modestly speed up to make it (safely) through the intersection on green
- Energy Savings: 10% - 20%
- Smoother Traffic Flow

Source: Nobis, November 2013
Eco-Approach and Departure Truck Demonstration Event

• March 6, 2019 in Carson, CA

• 1st Eco-Drive demo in L.A. region with demo rides given to over 50 invited attendees

• Partnership between 10 public agencies, 6 technology providers, 1 trucking companies, Volvo, and UCR
Implementation Scenarios - Policy and Regulatory Levels

Possible Adoption of Formal Policies:

- Local and regional transportation and land use departments use their authority to limit the use of certain routes by heavy-duty trucks or designate low-exposure truck routes
  - City of San Bernardino
  - San Bernardino County Transportation Authority
  - California Department of Transportation (Caltrans) District 8

- Air quality regulators adopt indirect source rules that mandate or incentivize alternative routing or geofencing technologies
  - South Coast Air Quality Management District
  - Example: SCAQMD’s Proposed Rule 2305 - Warehouse Indirect Source Rule
Implementation Scenarios - Policy and Regulatory Levels

Possible Voluntary Actions by Firms:

• New industry-level norms: firms adopt low-impact emissions routing guidelines
  • The logistics sector uses emerging routing technologies to divert heavy-duty truck traffic to
    low-impact routes, accepting a tradeoff between slightly increased delivery time/distance for
    reducing inhalant exposure of PM 2.5 and NOx to communities and sensitive receptors
  • Bonus: slight reduction in fleet average fuel consumption

• Industry- or firm-specific leaders adopt new standards in the Inland Empire
  • Amazon, the region’s largest private-sector employer, pilots innovative alternative routing and
    geofencing technologies for their delivery fleets in the IE
Thank You!